Space Weather Technical Forecast

Issued on Monday, 20 February 2023 at 01:09 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares (R1/R2) likely with an ongoing X-flare potential (R3). CME arrival expected early day 1 (20th), with a chance of G1/Minor Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with only C-class flares observed. There are nine sunspot regions, with the most noteworthy being AR3229 Ekc/Beta-Gamma-Delta in the northwest, which is a moderately sized and complex region. A small delta spot is present to the south of its leader, with ongoing slow growth in penumbra area. This region also has some notable magnetic looping above the spot, adding to its potential eruptive nature. The other regions are all smaller and simpler, with the only other growth observed being largely limited to new and emergent regions, or AR3225 Dai/Beta that is now rotating away over the southwest horizon. Two CMEs were observed leaving the Sun from the southwest disc due to filament eruptions. The first was a clear miss, however the second, erupting from near AR3217 in the southwest has a small chance to give a glancing interaction late on day 3 or early day 4 (22nd or 23rd).

Solar Wind / Geomagnetic Activity: Solar winds as measured by DSCOVR at L1 were at background, easing from 400 km/s to just over 300 km/s. Density was near or below average. The total IMF strength, Bt, was Weak below 7nT. The north-south component, Bz, varied weakly between +5nT and -4nT. Phi angle was largely positive (away from the Sun) but with some variability after 19/1200 UTC. Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. High energy electron flux (greater than 2MeV) at GOES16 was at largely background levels. The associated 24 hour electron fluence has been well below the Active (1e8 integrated pfu) threshold, reaching 7.47e6 integrated pfu at 20/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity expected, with isolated M-flares likely, but also a slight chance of rising again to High with further X-flares. The main risk for further significant flaring is AR3229 in the northeast.

Solar Wind / Geomagnetic Activity: CME associated with the X2.2 flare on the 17th has been assessed to have an Earth-directed shock component, albeit with most of the material missing to the east, behind Earth. This is anticipated to arrive early day 1 (20th) leading to elevated solar winds (500-600 km/s) being possible. The impact of any arrival is low confidence, however. These winds then easing day 2 (21st), before a further slight enhancement occurs from the arrival of CH77 fast wind later day 2 or day 3 (22nd). There is a very low chance of a further CME glance later day 3 or day 4 (23rd), but currently not expected. Geomagnetic activity is forecast to rise on day 1 (20th) to be Active with a chance of G1 Minor Storms perhaps lasting into day 2 (21st), before easing to be Quiet to Unsettled. The further enhancement later day 2 or day 3 (22nd or 23rd) is expected to be relatively muted, perhaps bringing a spell of Active

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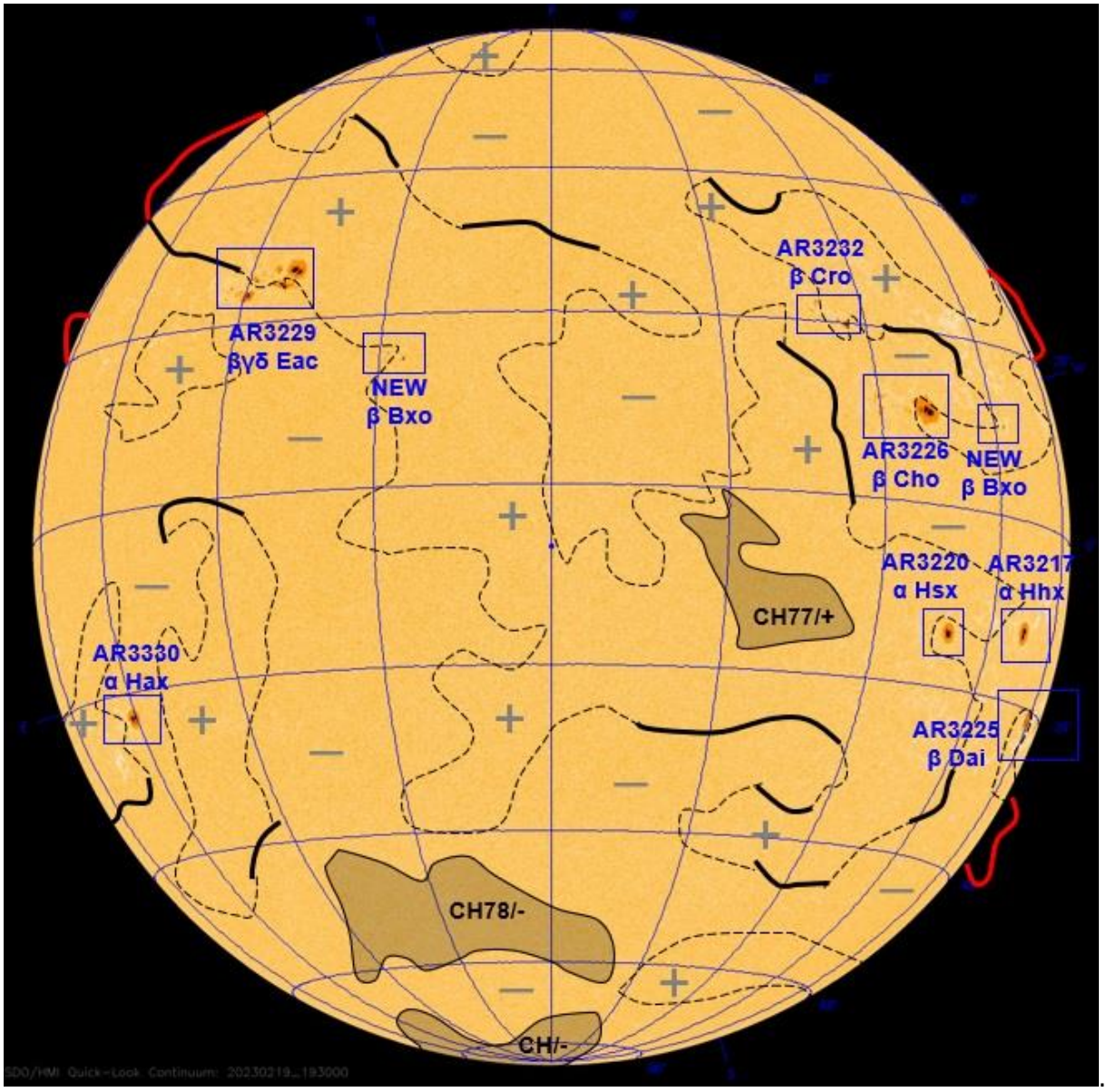
conditions, before easing again.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at background levels, but with a slight chance of rising towards the S1 level, perhaps exceeding it if any larger flares occur. High energy (greater than 2 MeV) electron flux may increase later in the forecast period in response to the fast wind enhancement, however this is low confidence. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

Figure 1. Solar Analysis Valid 19/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A fast CME was observed on 17th with the X2.2 flare from AR3229. The majority of the ejecta is directed away from Earth, towards the east, however a clear halo shock was visible in coronagraph imagery. Analysis of such shocks and their expected impact carry additional uncertainty regarding how impactful they will be on arrival. However this is expected to arrive early day 1 (20th). There is also a CME from a filament eruption on the 19th, which is expected to miss to the south and west (ahead of Earth), but may give a glancing interaction late on day 3 or early day 4 (22nd or 23rd).

A further enhancement is also likely late day 2 or 3 (21st or 22nd) from the arrival of fast wind from CH77/+. This is a persistent feature, although appears a little more ragged on imagery on this occasion. Furthermore, any enhancement is likely to be fairly muted due to its positive polarity being disfavoured for connection close to the March Equinox.

Geomagnetic activity is forecast to rise to Active with G1 Minor Storms likely and a slight chance of G2 Moderate storms, along with the CME arrival on day 1 (20th). These effects could last into day 2 (21st), however once it does pass activity is expected to be Quiet to Unsettled. Any further enhancement later day 2 or day 3 (22nd or 23rd) for the CH77 HSS is expected to be relatively muted, with a spell of Active conditions likely, and only a slight chance of G1 Minor Storms, before easing back to be mainly Quiet with Unsettled intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	20	10	10
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/0145	Full	X2.2 of AR3229	NE	700km/s	20/0600 UTC	Low confidence on impacts. Shock only – with ejecta missing
19/2320	Partial	Filament eruption nr AR3217	SW	662 km/s	Missing	Small chance of glance late 22nd or early 23rd

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Figure 2a: Enlil and ensemble showing two potential CME arrivals. The latter is expected to miss.

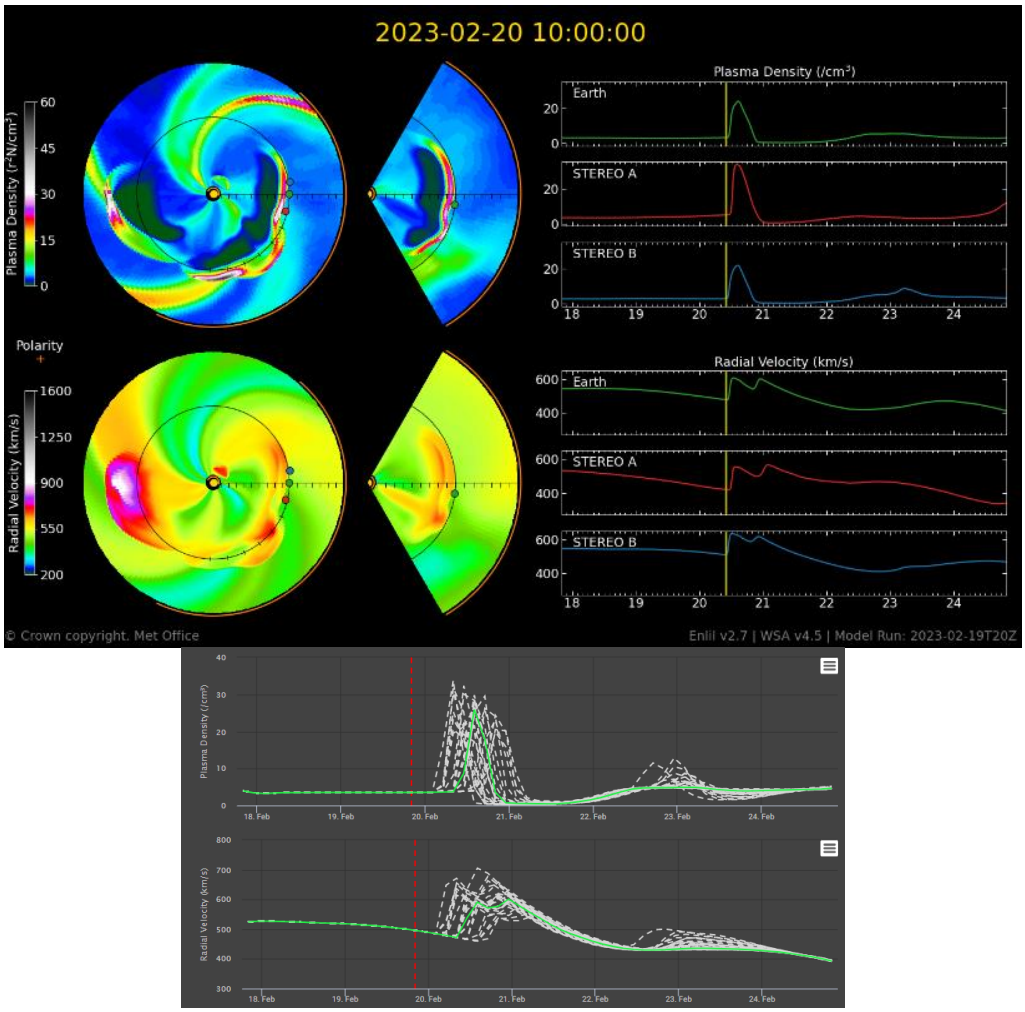
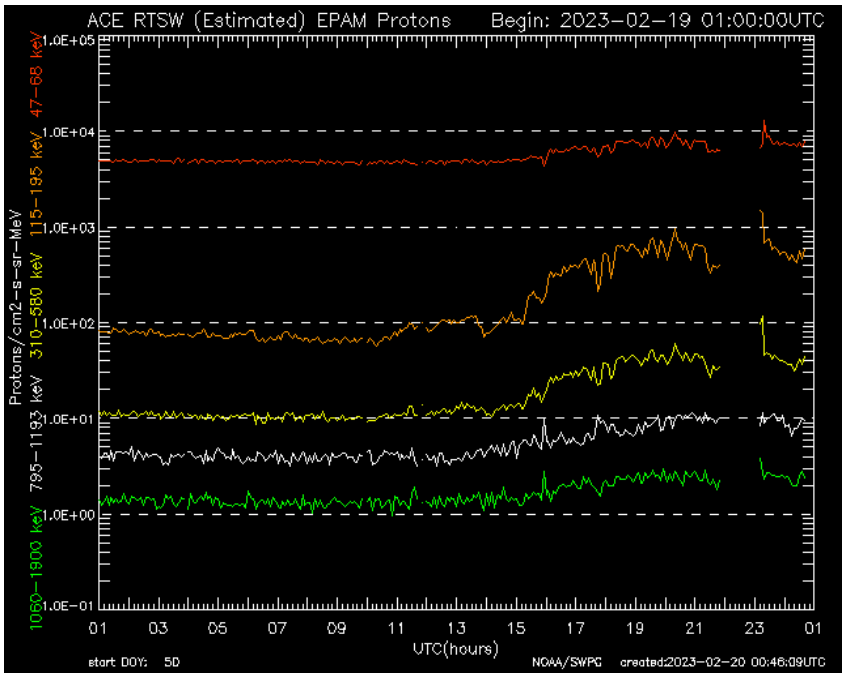


Figure 2b: ACE EPAM, showing a small rise in low energy protons. This can often be observed ahead of a CME arrival.



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Radio Blackouts - X-Ray Flares:

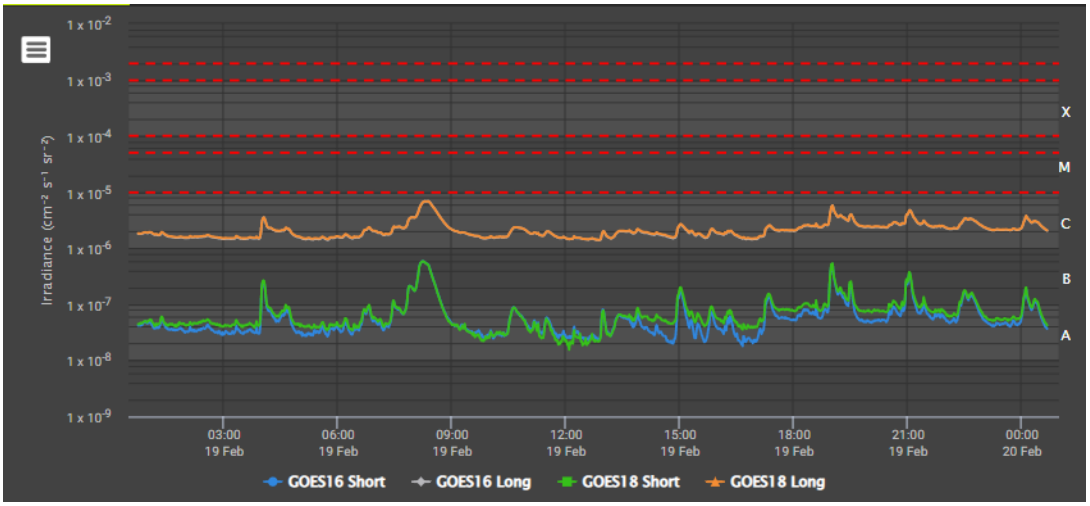
Low to Moderate activity is expected through the period, with isolated M-flares possible. There remains a slight chance of an X-class flare. There are a total of nine sunspot regions on the disc

The main focus of potential activity remains AR3229 Ekc/Beta-Gamma-Delta. Despite a relatively modest size, this region continues to show complexity, with a small delta spot present in amongst its intermediate regions. Furthermore SDO aia-304 also showers a large filament that is connected to this region, while SDO aia-94 continues to show some distinct looping above the spot, potentially due to a weak perhaps sigmoid-type structure that can be indicative for the potential of eruptive flares. Given this region has a history of strong flaring with the X2.2 on the 17th, further similar events remain possible.

The other regions are generally smaller and simpler, with the only observed development amongst the new small emergent spots or AR3225 Dai/Beta soon rotating off the disc. Conversely, previously large but stable spot AR3226 Cho/Beta has been seeing some notable decay.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	55	50	40	30
Very Active	R3 to R5 X Class	No	20	15	15	10

Figure 3: GOES-16/18 X-ray Flux



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Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. A proton response was not observed from the X2.2 flare on the 17th, however there remains a chance of further strong flares from this region. There are also a couple of spots in the western hemisphere that have the potential for M-flaring, which is a more favoured location for Earth-directed proton events. This gives an ongoing slight chance of proton count rates increasing towards, or breaching the S1 Minor Radiation Storm threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4a: SDO Intensitygram and Magnetogram of AR3229

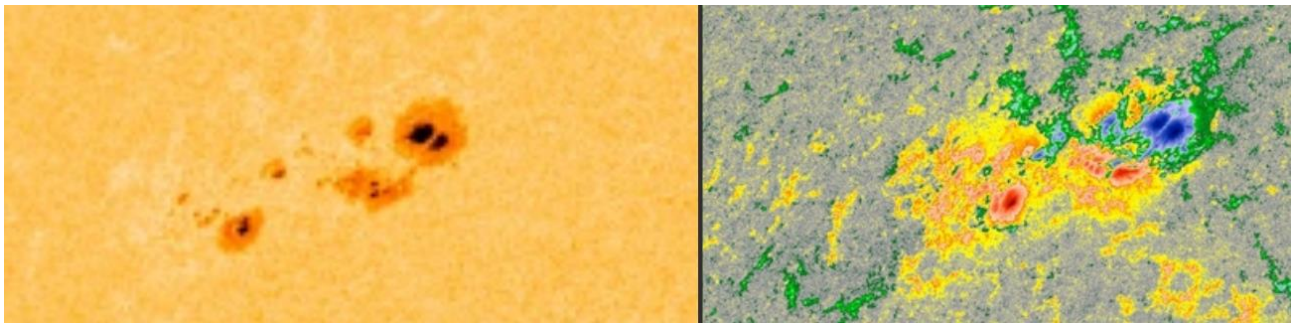
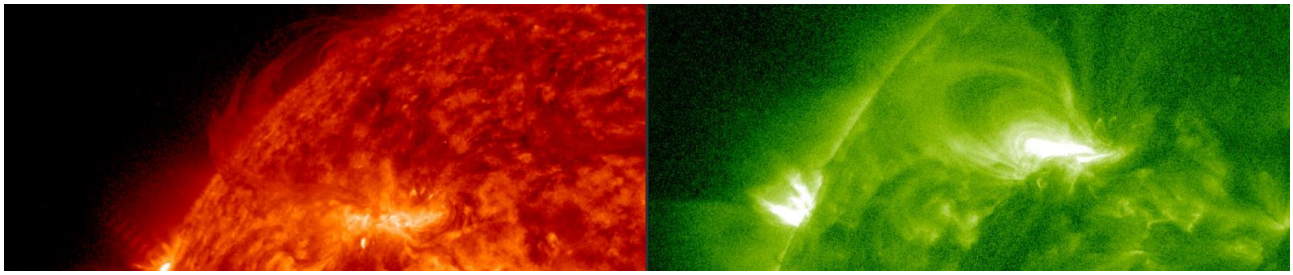


Figure 4b: SDO aia 304 and aia-94 of AR3229. The former shows a large filament connected to the region, with the later showing the magnetic structure over the spot.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed at GOES-16 is currently at Background levels. Any more persistent increase in flux is likely to be suppressed by a CME arrival on day 1 (20th). Some recovery towards Moderate levels is then likely after the onset of the CH77 HSS, later day 3 or during day 4 (21st or 22nd). There is a slight chance this may approach high levels by the end of the period.

The associated 24 hour fluence is expected to remain below the Active threshold, with only a slight chance of rising above later in the period. REFM maintains below Active fluence, and this is likely to be a reasonable guide through the period.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	1	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: GOES-16 >2MeV Electron flux and associated fluence with REFM

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